LATE PALEOZOIC AND EARLY MESOZOIC CHAROPHYTA.

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The Charophyta are a group of small plants of doubtful systematic position, ranked by some investigators as a class of the Thallophyta and by others as a separate phylum. They are widely distributed in clear fresh water and a few have been noted in the Baltic Sea,[1] a marine body of water with an unusually low mineral content. The group is rather inconspicuous and being of no economic value has attracted very little attention except among botanists. It is, however, of interest to geologists in that some species secrete calcium carbonate and are large contributors to fresh water limestones. It has been shown by Reid and Groves[2] that the fossil remains can be of great value in correlating fresh water deposits, and my investigations indicate that they can be of aid in correlating rocks as old as the Devonian.

Although many of the living charophyte plants are completely encrusted by calcium carbonate it is seldom that any recognizable organic structures are preserved except the spiralled oogonia. This is especially true in rocks older than the Cenozoic. On the death of the plant, the encrustation usually breaks down into a fine-grained calcareous mud.

Fossil charophyte oogonia consist of the calcium carbonate that was deposited on the interior of the spiral enveloping cells. On the living plants this deposition starts on the concave inner walls of the enveloping cells adjoining the oosphere and may replace almost the entire cell substance. In different stages of calcification the exterior of the "lime-shell" varies greatly in appearance. If only a thin deposit is made the oogonium will possess very sharp spiral ridges (see figure 7) with wide, deep concavities, the ridges representing the lateral union of the cells and the concavities the cells. If deposition continued, the cells of the fossil oogonium may be represented by broad spiral ridges (see figure 12) and the lateral union of the cells by narrow furrows. Any stage between the "concave cells" and the "convex cells" may occur in the same

[1] Groves, James, and Bullock-Webster, G. R., British Charophyta: Ray Society, London, 1, page 6, 1920.

[2] Reid, Clement, and Groves, James, The Charophyta of the Lower Headon Beds of Hordle Cliffs: Quart. Jour. Geol. Soc., London, 77, pp. 175-192, 1921.

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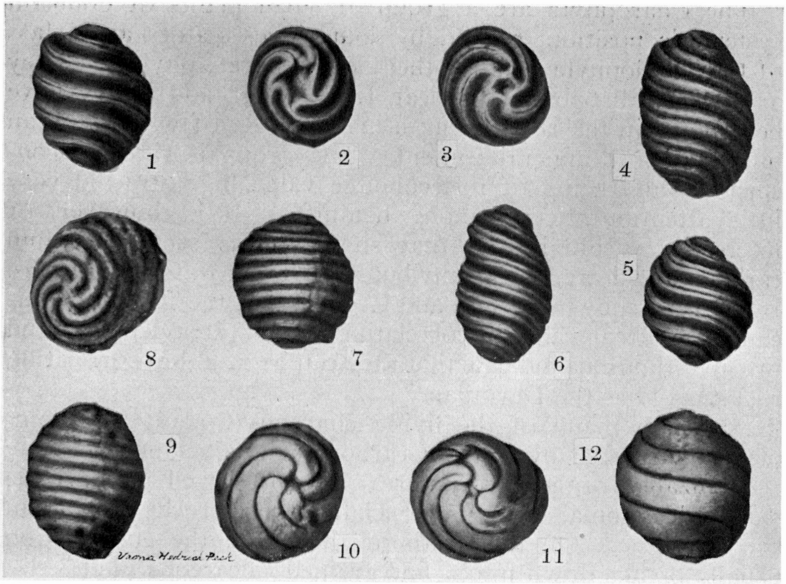
species and, in rare cases, on the same oogonium. The oogonia of all living Charophytes have five sinistrally spiralled enveloping cells, and the majority of fossil oogonia have five sinistrally spiralled ridges. These five spiralled oogonia are locally



EXPLANATION OF PLATE.

All specimens x 54.

Figs. 1-3, 5, 6. Gyrogonites moreyi, n. sp.
Figs. 1-3. Lateral, summit, and basal views of the holotype.
Figs. 5, 6. Lateral views of paratypes showing variations in shape.
Fig. 4. Gyrogonites sp.
Figs. 7-9. Gyrogonites glyptus, n. sp. (cotypes).
Fig. 7. Lateral view of a crushed oogonium.
Fig. 8. Basal view of a crushed oogonium.
Fig. 9. Lateral view of an oogonium of normal shape.
Figs. 10-12. Gyrogonites robertsi, n. sp.; basal, summit, and lateral views of the holotype.

abundant in the Cenozoic, occur sparingly in the Cretaceous of Europe and North America, and have been noted in the Jurassic of Europe.[3]

The only undisputed record of sinistrally spiralled charophyte oogonia older than Jurassic, except those here reported,

[3] Groves, James, and Bullock-Webster, G. R., British Charophyta: Ray Society, London, **2**, page 78, 1924.

is that of *Palaeochara acadica* Bell,[4] a six spiralled species from the Carboniferous of Nova Scotia. However, dextrally spiralled oogonia, thought to represent another family of the Charophyta, are locally abundant in the Devonian and lower Mississippian.

In 1856, Pander[5] noted the occurrence of two groups of small organisms from the Devonian of Russia under the name Trochilisken. One group closely resembles the charophyte oogonia in appearance but possesses from seven to ten spirals ascending dextrally. The other group, closely associated with the spiral forms, has from sixteen to twenty vertical units. These forms have since been noted at various localities and horizons within the Devonian and lower Mississippian of Europe, North America, and Africa, and have been described under the generic names *Calcisphaera* Williamson, *Moellerina* Ulrich, *Sycidium* G. Sandberger, and *Trochiliscus* A. Karpinsky. They have been classified as lycopod spores, phyllopod eggs, fish eggs, echinoids, foraminifera, and charophytes. Karpinsky,[6] in an excellent monograph on the European forms, discussed their systematic relationships and gave considerable evidence pointing to their charophyte affinities. I have been fortunate in having recently had the opportunity of studying a large number of exceptionally well preserved specimens from the Devonian and lower Mississippian of North America. The results of this investigation, giving new evidences indicating the relationship of these problematic forms with the Charophyta, appears in another journal.[7] In that paper I have introduced a tentative classification to include the living and fossil Charophyta. The group is divided into three families. One family, the Sycidiaceae, has a large number of vertical units and is evidently most nearly representative of the ancestral charophytes. The Trochiliscaceae, always with a lesser number of units than the Sycidiaceae, are oogonia with a dextral spiral. The third family, the Characeae, possess sinistrally spiralled oogonia, and includes the living charophytes as well as a large number of fossil forms. The Charophyta must have originated as a well

[4] Bell, W. A., A New Genus of Characeae and New Merostomata from the Coal Measures of Nova Scotia: Roy. Soc. Canada, Proc. and Trans., 3d ser., **16**, pp. 159-168, 1922.

[5] Pander, Christian H., Monographie der fossilen Fische des Silurischen Systems des russischbaltischen Gouv., p. 17, 1856.

[6] Karpinsky, A., Die Trochilisken: Memoires Du Comite Geologique, Nouvelle serie, Livraison 27, pp. 1-165, 1906. (Russian and German.)

[7] Jour. Pal. (in press).

defined group before the Devonian for in the lower Devonian the families Sycidiaceae and Trochiliscaceae are well represented. The fossil record depends on, first, when the group acquired the ability to secrete calcium carbonate, and second, when it became extinct. Many living species of charophytes do not secrete calcium carbonate and are not known as fossils. As our records now indicate, two families acquired the ability to secrete calcium carbonate in the Devonian and became extinct in the lower Mississippian.

Considering this ancient record it is surprising that the Characeae have not, with the exception of the single occurrence of *Palaeochara acadica* Bell, been noted below the Jurassic. Through the kindness of Dr. E. B. Branson and several students engaged in micropaleontology at the University of Missouri I have greatly extended the record of five celled, sinistrally spiralled oogonia by specimens from the Pennsylvanian, Permian, and Triassic? periods. I am indebted to Dr. E. B. Branson for valuable suggestions and criticisms offered during the preparation of this manuscript, and for his short discussion on the age of the upper Chugwater formation.

The classification of the living Charophyta is based largely on the non-calcified coronula cells and other details of the soft anatomy of the plants. For that reason it is difficult in most cases to give fossil oogonia the proper generic assignment. It has long been the custom of paleobotanists to refer most fossil oogonia with five sinistral spirals to the genus *Chara*. In 1927, Pia[8] pointed out that it is extremely unlikely that all oogonia grouped under the genus *Chara* could belong to it and that it might be better to refer fossil oogonia of doubtful affinities but with five sinistral spirals to the generic name under which they were first described, *Gyrogonites* Lamarck. Although this leaves the genus *Gyrogonites* without restrictions and more or less of a group name, in the present state of our knowledge it seems to be the best method available.

FAMILY CHARACEAE.

GENUS GYROGONITES LAMARCK.

Gyrogonites glyptus, n. sp.

(Plate 1, figures 7-9.)

Oogonium subspherical, small, ranging from .3 to .4 mm. in height, higher than wide, with greatest transverse diameter

[8] Pia, Julius, Hirmer's Handbuch der Paläobotanik, Band 1, p. 88, 1927.

slightly above mid-height. Spiral ridges intercellular, narrow, closely spaced, and making approximately two complete turns. Ten ridges visible in a lateral view.

Occurrence.—Algae Bed of the Chugwater formation near Lander, Wyoming. Dr. E. B. Branson (personal correspondence) has given his opinion on the age of this horizon as follows:

"Along the east flank of the Wind River Mountains in Wyoming the Chugwater group of the Triassic is 1400 to 1600 feet thick. It is largely of red fine-grained sandstone, but gypsum makes up more than 100 feet of it in many places. It may conveniently be divided into the members listed below:

Upper Chugwater. Fine grained red sandstone, gypsum beds, and thin limestone members, about 600 feet.

Popo Agie beds. Continental and near shore sandstones, shales, and conglomerates, 30 to 100 feet.

Middle Chugwater. Fine grained red sandstone, about 200 feet.

Alcova limestone. Dense dolomitic limestone, 1 to 20 feet.

Lower Chugwater. Fine grained red sandstone, about 600 feet.

"One of the thin limestone members about 30 feet from the top of the upper Chugwater contains many plant remains, probably algae, and the Charophyta described by Dr. Peck. The age of upper Chugwater has generally been considered as upper Triassic but recently it has been referred to the Sundance formation (Jurassic) by some writers.[9] However, the evidence for its Triassic age is strong and for Jurassic age weak.

There is an important unconformity between the upper Chugwater and the Sundance.

It contains no Jurassic fossils, definitely identifiable as such, and animals should have come in with an advancing sea.

The presence of a few fossils representing aberrant types that lived under unfavorable conditions represent a continuation of Chugwater conditions.

The presence of extensive gypsum deposits and of widespread thin limestone members formed as chemical precipitates indicate continuation of Chugwater conditions. Advancing seas are unfavorable for chemical precipitates of either lime or gypsum."

[9] Reeside, J. B., Journal of Geology, **37**, p. 50, 1929.
Bartram, John G., Journal of Geology, **38**, p. 341, 1930.

Gyrogonites moreyi, n. sp.

(Plate 1, figures 1-3, 5, 6.)

Oogonium subovate to ovate-rotundate, ranging from .3 to .4 mm. in height, higher than wide, greatest transverse diameter at or usually below mid-height. Spiral ridges intercellular, fairly broad, making a little more than one complete turn around the oogonium. At the center of each ridge is a fine furrow marking the lateral contact of the cells. The furrows separating the ridges are approximately equal to the ridges in width.

Occurrence.—Cherokee (Pennsylvanian) shale about thirty-five feet above the Bevier coal at the Brick Plant, Columbia, Missouri; ?Winterset (Pennsylvanian) from Quarry at Swope Parkway and Prospect, Kansas City, Missouri; ?Waubaunsee (Pennsylvanian) near Manhattan, Kansas.

Holotypes and Paratypes.—Catalog numbers 31007-3, 31007-4, University of Missouri.

Approximately one hundred specimens of *G. moreyi* have been collected from the Cherokee by Mr. John Roberts and Mr. Philip Morey. They differ slightly in the length-width ratio, as is shown in the accompanying illustrations.

A single specimen has been collected from the Winterset limestone and another from the Waubaunsee formation. These forms are too poorly preserved to permit specific identifications and I am tentatively referring them to *G. moreyi.*

Gyrogonites robertsi, n. sp.

(Plate 1, figures 10-12.)

Oogonium globose, about .4 mm. in height, higher than wide, greatest transverse diameter slightly above mid-height. Spiral ridges cellular in position, broad, gently convex, making one complete turn around the oogonium. Narrow shallow furrows between the ridges mark the lateral contact of the cells.

Occurrence.—Cherokee (Pennsylvanian) shales about thirty-five feet above the Bevier coal at the Brick Plant, Columbia, Missouri.

Holotype. — Catalog number 31007-2, University of Missouri.

G. robertsi differs from all other recorded Pennsylvanian charophyte oogonia in having broad, gently convex ridges, the result of having the enveloping cells almost filled with calcium carbonate. It also differs from *G. moreyi* in shape and in the spirals making but one complete circuit.

The single specimen, the holotype, was collected by Mr. John Roberts. It was taken from the same sample that yielded a considerable number of *G. moreyi*, and a variety of ostracods, conodonts, and fusilinids.

Gyrogonites sp.

(Plate 1, figure 4.)

A single oogonium was collected from the Council Grove shale west of Manhattan, Kansas, by Mr. H. G. Walter. Although there is considerable doubt as to the Pennsylvanian-Permian contact in this area, the line is drawn at the base of the Council Grove on the United States Geological Survey correlation chart for Oklahoma and by most investigators. A brief discussion on this question is given by Condra and Upp.[10] The specimen is too poorly preserved to allow specific identification but I am noting it because of its importance as the first charophyte record from the Permian.

Figured Specimen.—Catalog number 31007-1, University of Missouri.

[10] Condra, G. E., and Upp, J. E., Correlation of the Big Blue Series in Nebraska: Nebraska Geol. Surv. Bull. 6, 2d ser., p. 14, 1931.

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